Some hindcast simulations of an ensemble of MJO events

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We are at the dawn of an exciting phase in global modeling

REVOLUTIONIZING CLIMATE MODELING WITH PROJECT ATHENA

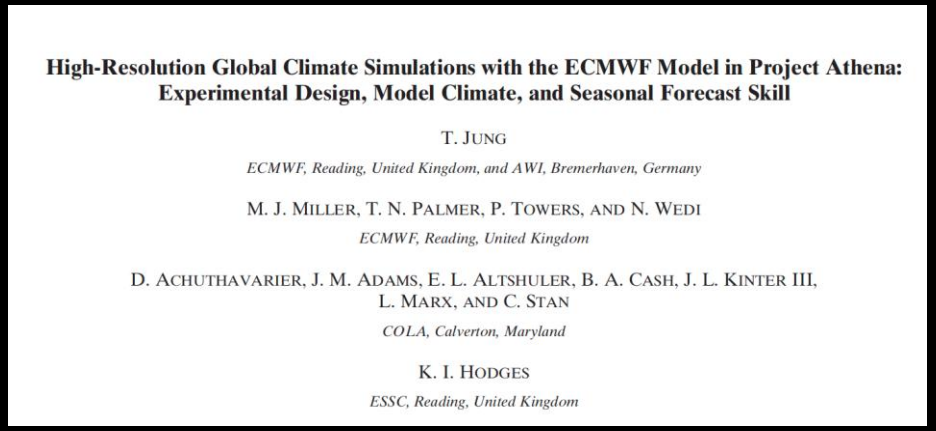
A Multi-Institutional, International Collaboration

BY J. L. KINTER III, B. CASH, D. ACHUTHAVARIER, J. ADAMS, E. ALTSHULER, P. DIRMEYER, B. DOTY, B. HUANG, E. K. JIN, L. MARX, J. MANGANELLO, C. STAN, T. WAKEFIELD, T. PALMER, M. HAMRUD, T. JUNG, M. MILLER, P. TOWERS, N. WEDI, M. SATOH, H. TOMITA, C. KODAMA, T. NASUNO, K. OOUCHI, Y. YAMADA, H. TANIGUCHI, P. ANDREWS, T. BAER, M. EZELL, C. HALLOY, D. JOHN, B. LOFTIS, R. MOHR, AND K. WONG

ECMWF COLA JAMSTEC NICS

IFS 13-month Hindcasts	T159 T511 T1279	125 km 39 km 16 km
IFS 13-month Hindcasts	T2047	10 km
IFS 103-Day Hindcasts	T159 T511 T1279 T2047	125 km 39 km 16 km 10 km

An important lesson learned from the IFS Athena simulations



High-Resolution Global Climate Simulations with the ECMWF Model in Project Athena: Experimental Design, Model Climate, and Seasonal Forecast Skill

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ECMWF, Reading, United Kingdom, and AWI, Bremerhaven, Germany

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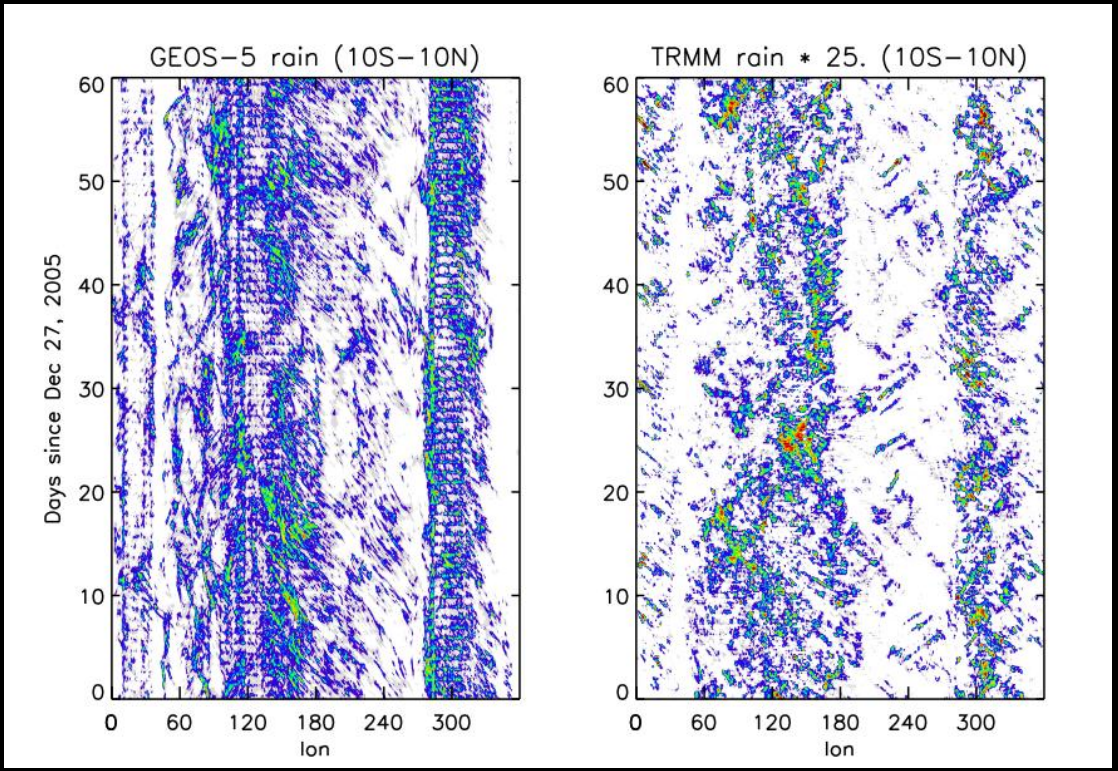
While increasing resolution improves several aspects of model perfomance (e.g., time-mean tropical rainfall pattern), “problems in simulating the MJO remain unchanged for all resolutions tested”

This finding is consistent with our own high-res. modeling



NASA GEOS-5 at ~12 km grid spacing (2-yr run) performed by Putman

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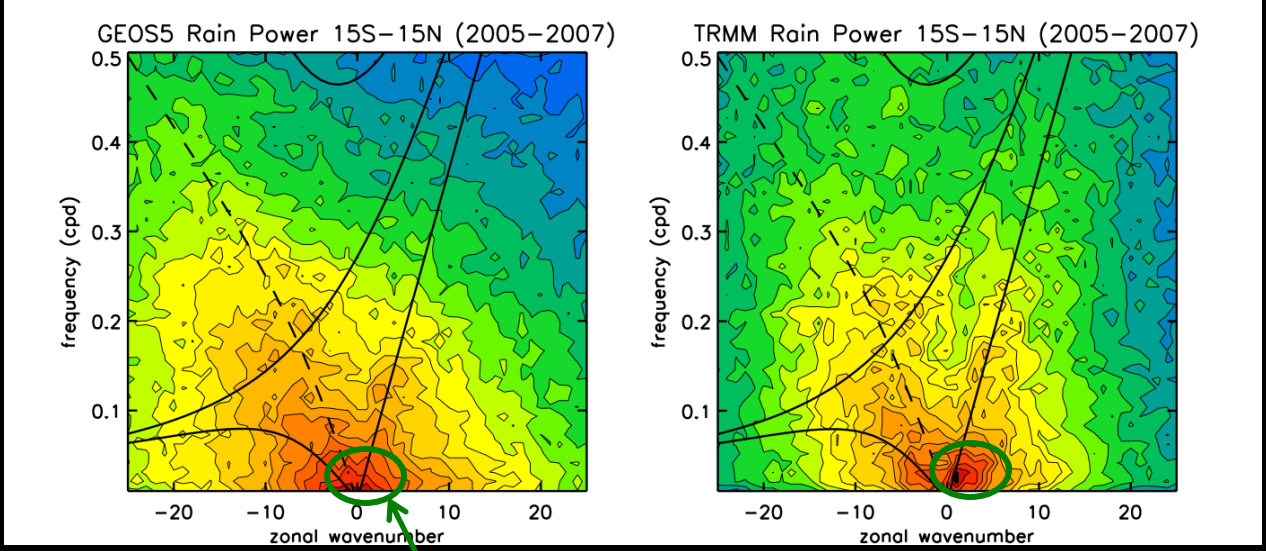


No spectral MJO peak

NASA GEOS-5 at ~12 km grid spacing (2-yr run) performed by Putman

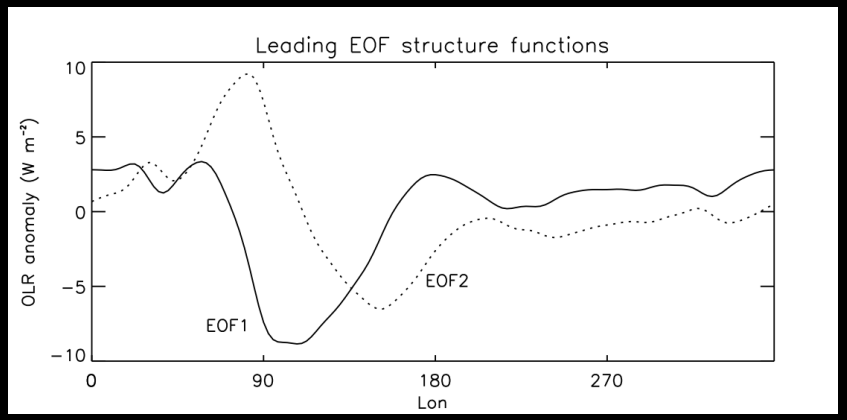
How do we improve depiction of the MJO in such high-resolution models?

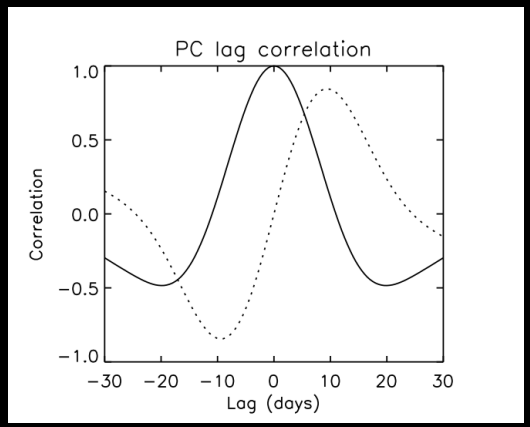
- Obviously, the standard approach of conducting long-term [O(10-yr)] simulations is not practical
- Alternatively, focusing on individual events can prove useful, but difficult to assess statistical robustness
- We propose an intermediate approach involving an ensemble of MJO events that are aligned in phase space (similar to the approach of Mike Pritchard at UC Irvine)

Defining the ensemble of MJO events

I. Perform an EOF analysis of NOAA OLR averaged between 10S-10N for 1979-2012

- Similar to the RMM approach, except that no wind information is used and the data is spectrally filtered to isolate the time and space scales of the MJO (eastward-moving k=1-20, periods of 100-20 days)

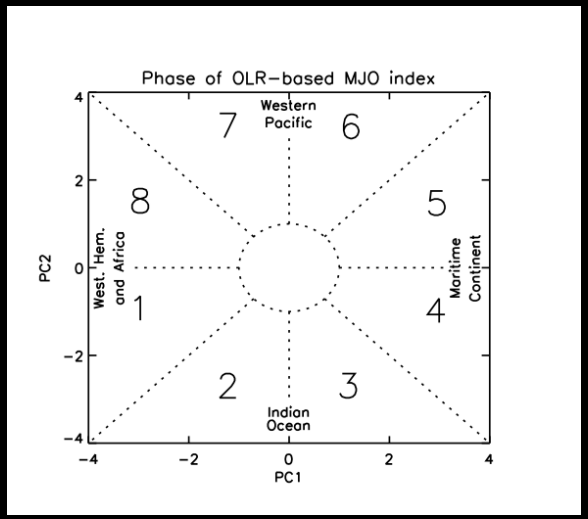




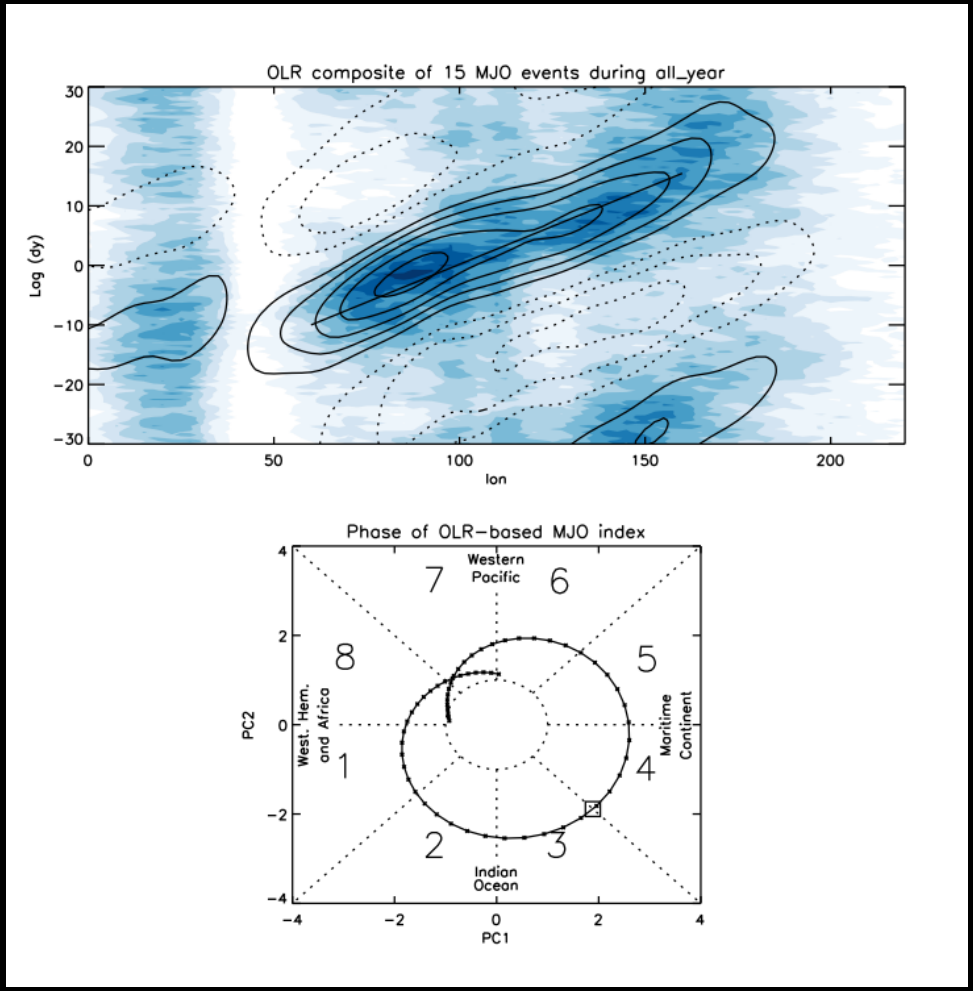
Defining the ensemble of MJO events

II. Devise criteria based on phase evolution of PCs

- Intended to capture large-amplitude, coherent events that reach maximum amplitude just east of the Maritime Continent



Composite evolution of the event ensemble

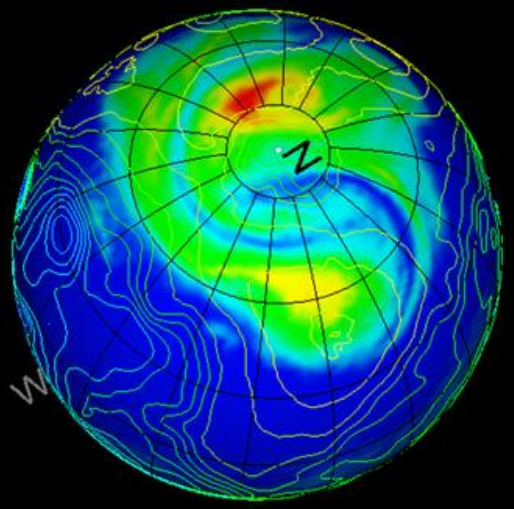


Details about the ensemble

- 15 events with dates at lag 0 occurring in all months except July; 3 events in Nov; 2 events in Dec
- 2 events correspond to YOTC MJO cases E and D in Waliser et al. 2012
- The Jan event corresponds to one of the two TOGA COARE events
- The March event corresponds to one of the DYNAMO events

Example of using the ensemble to assess and improve MJO model performance

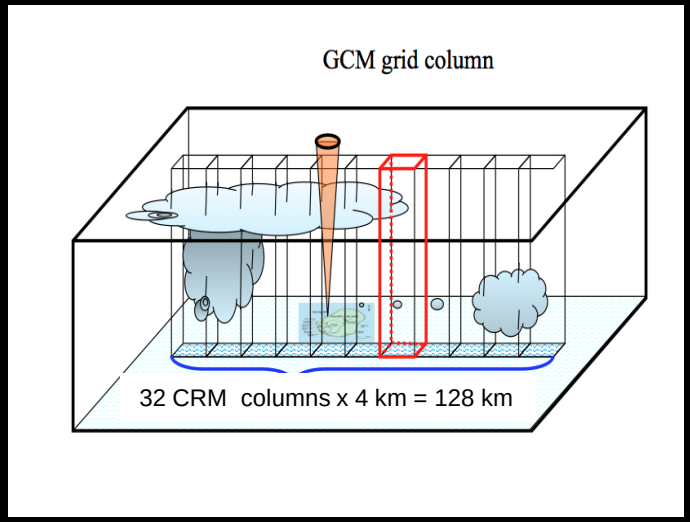
Specific model: “Superparameterized” version of the global Weather Research Forecast (WRF) model



Global WRF

Adv. tend.

App. sources



Why SP-WRF?

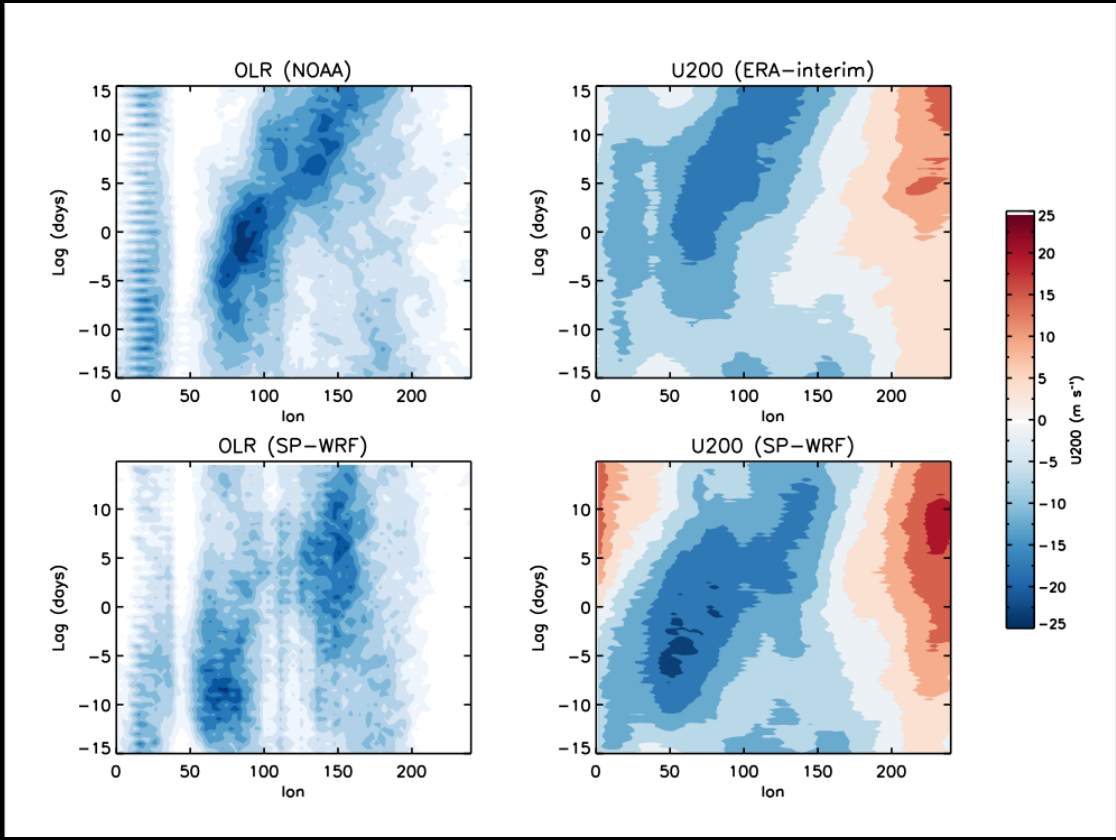
- WRF is a well-tested model that is used by numerous forecast centers around the globe including NOAA/NCEP (though exclusively in regional context)

- By definition, SP approach avoids the use of traditional conv. param. scheme
  - Focus on impacts of other parameterized physics packages (e.g., radiation, cloud microphysics, PBL mixing)
  - Testbed for global CRM development
  - SP does not require extensive tuning for changes in global model resolution

Details about the WRF hindcast process

- 15 hindcasts each lasting 30 days = 450 days in total
- Time-varying SSTs are prescribed using EC-interim data
- Prior to each 30-day run, model is nudged to EC-interim data for 5 days to allow CRM spinup
- Standard resolution is 2.8 deg. x 2.8 deg. with 51 levels; 32x4-km CRMs
- Runs are performed using NOAA computing resources (GAEA)
- Total ensemble requires ~185K Core Hours

Ens.-avg. SP-WRF 30-dy hindcast



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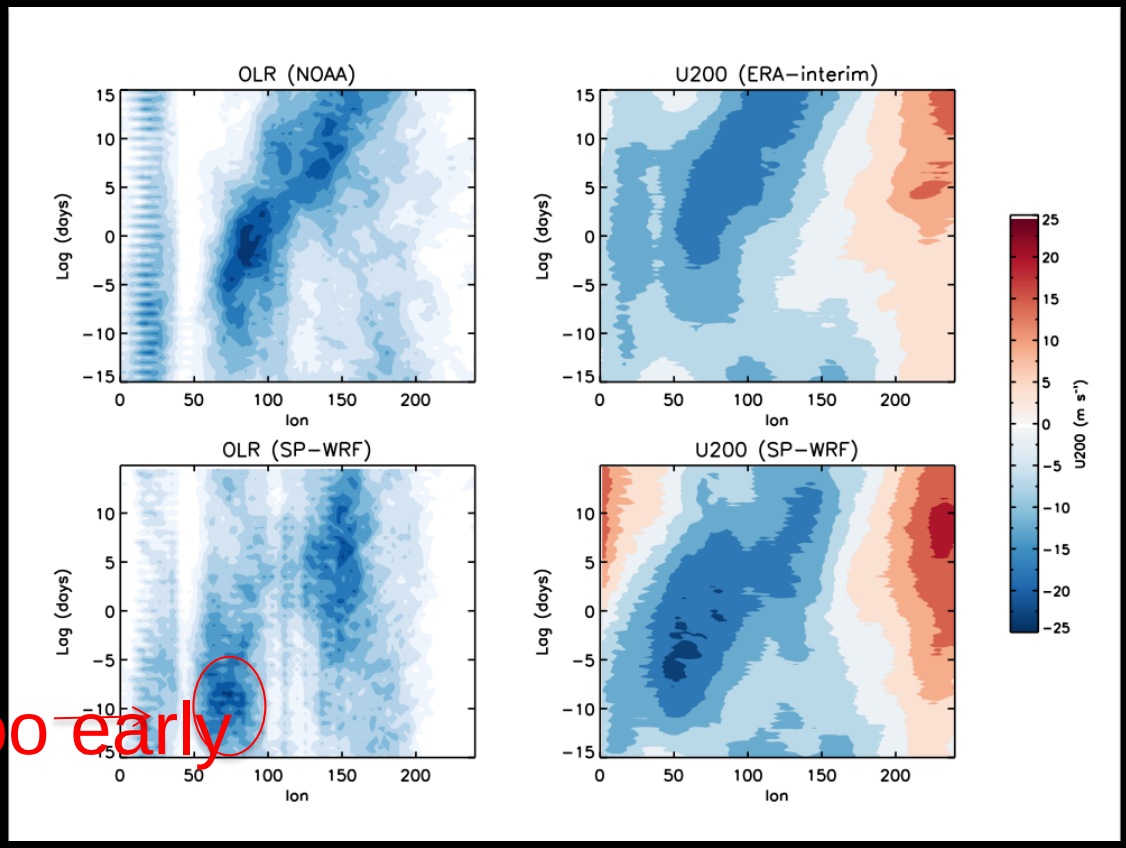
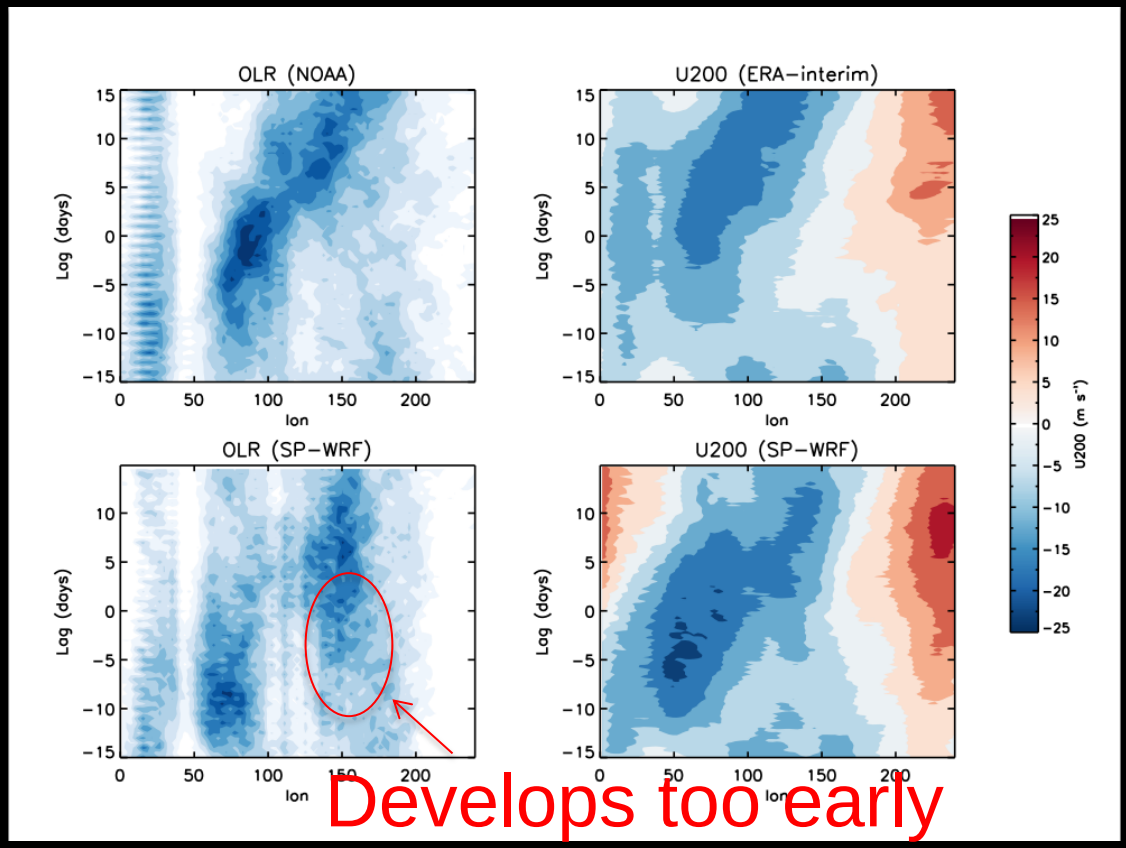


Peaks too early

Ens.-avg. SP-WRF 30-dy hindcast



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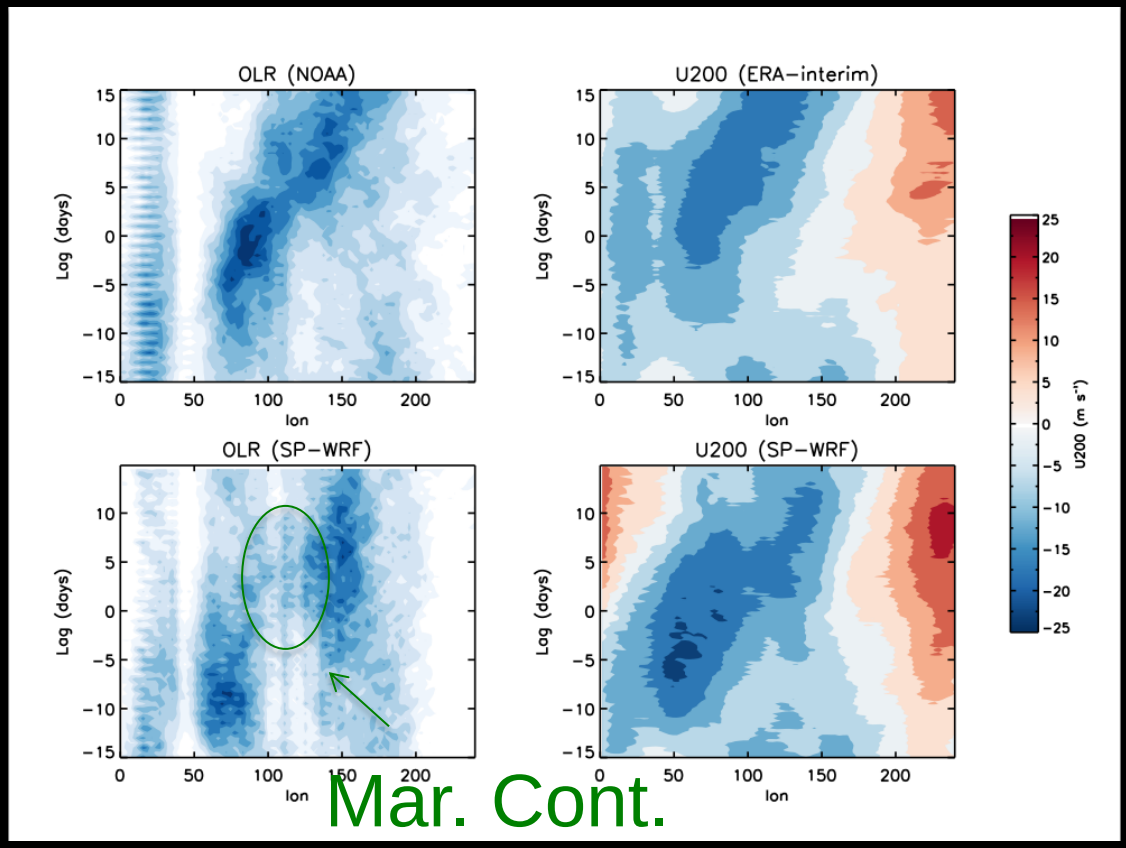

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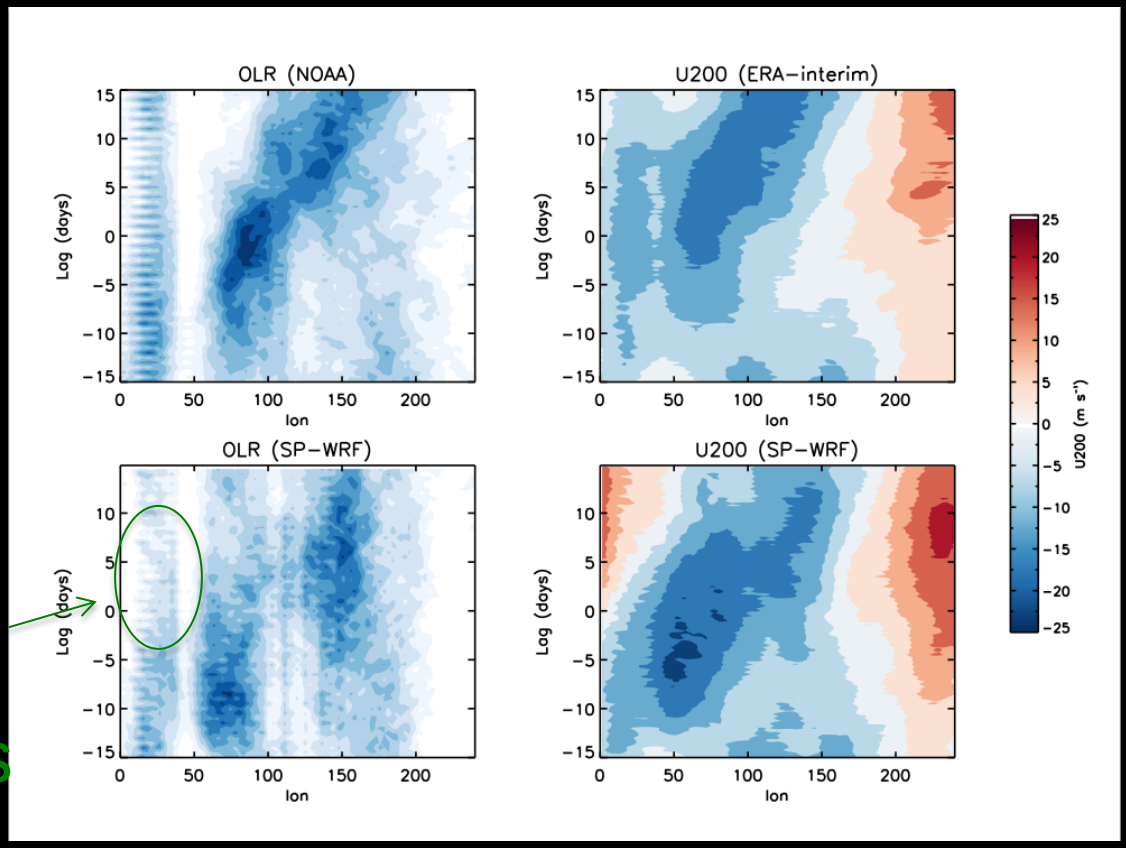
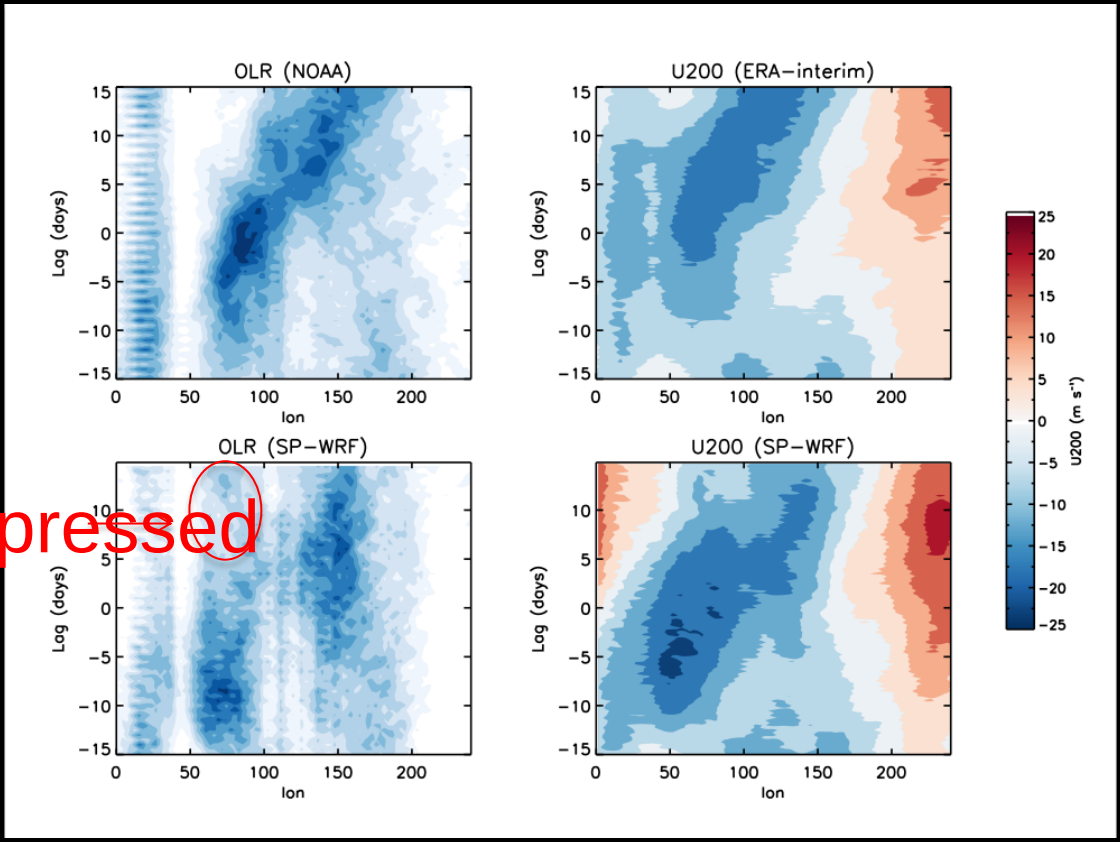


African conv. dies too much

Ens.-avg. SP-WRF 30-dy hindcast

Not suppressed enough



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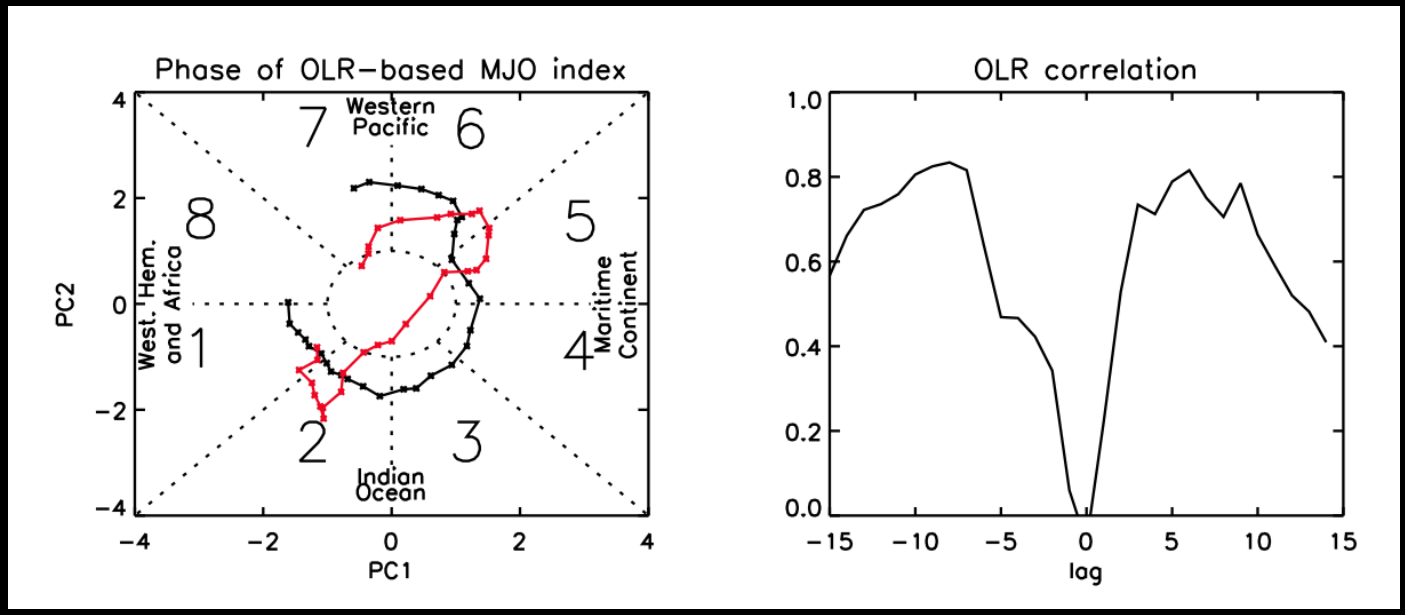
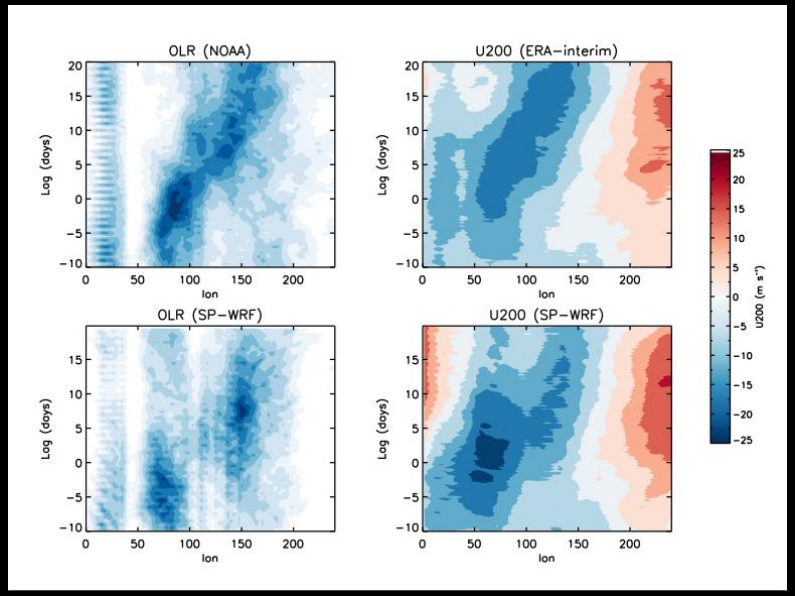
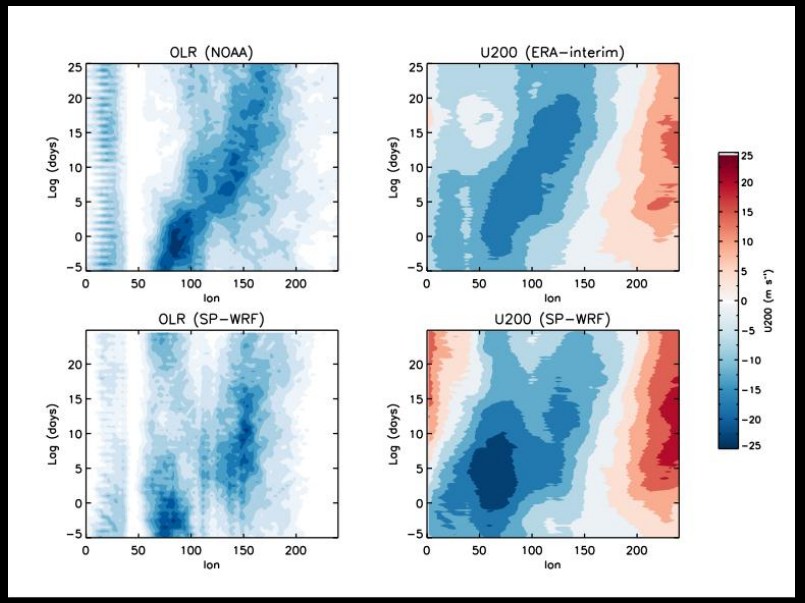


Looking at later start dates

-10 days



-5 days



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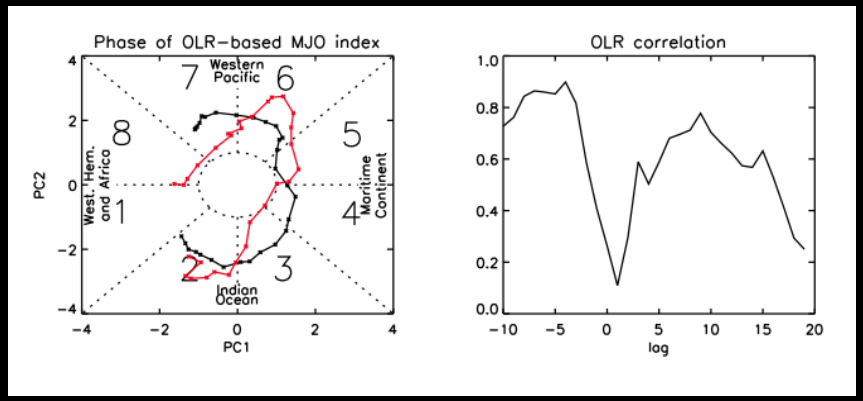

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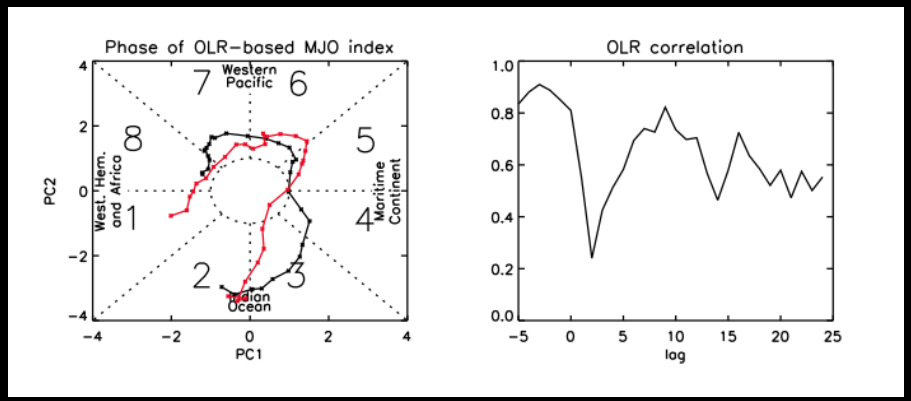
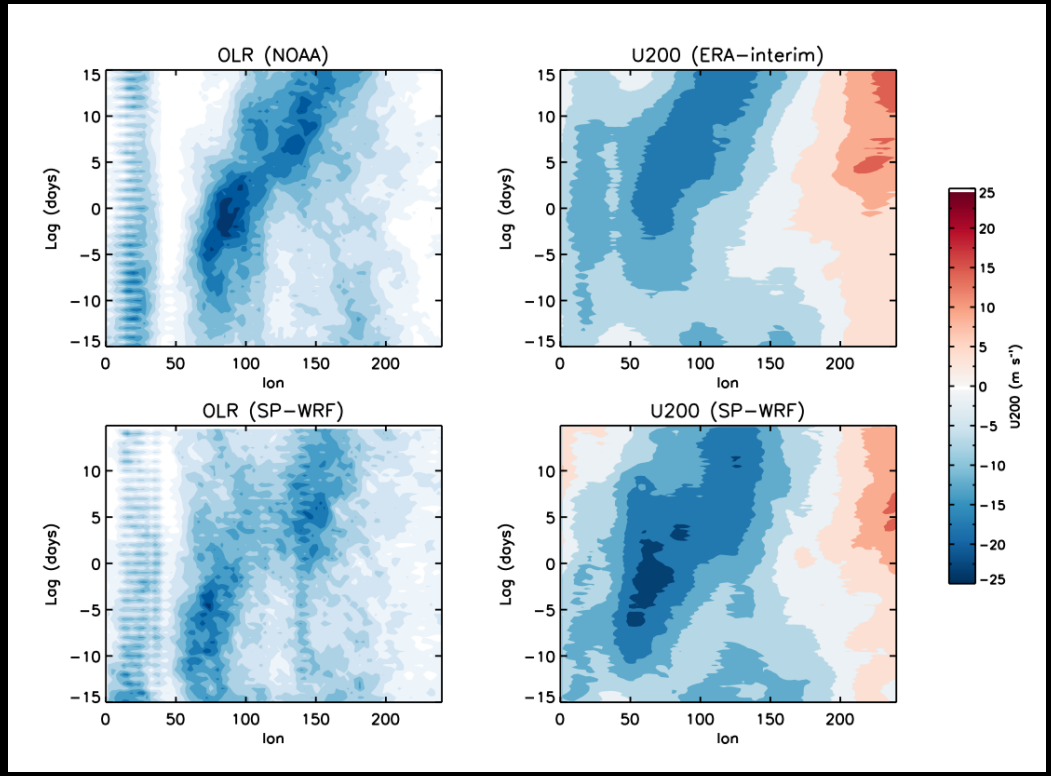


What is the effect of changing horizontal resolution?



0.7 x 0.7 deg with 8x4km CRMs; 8x more expensive

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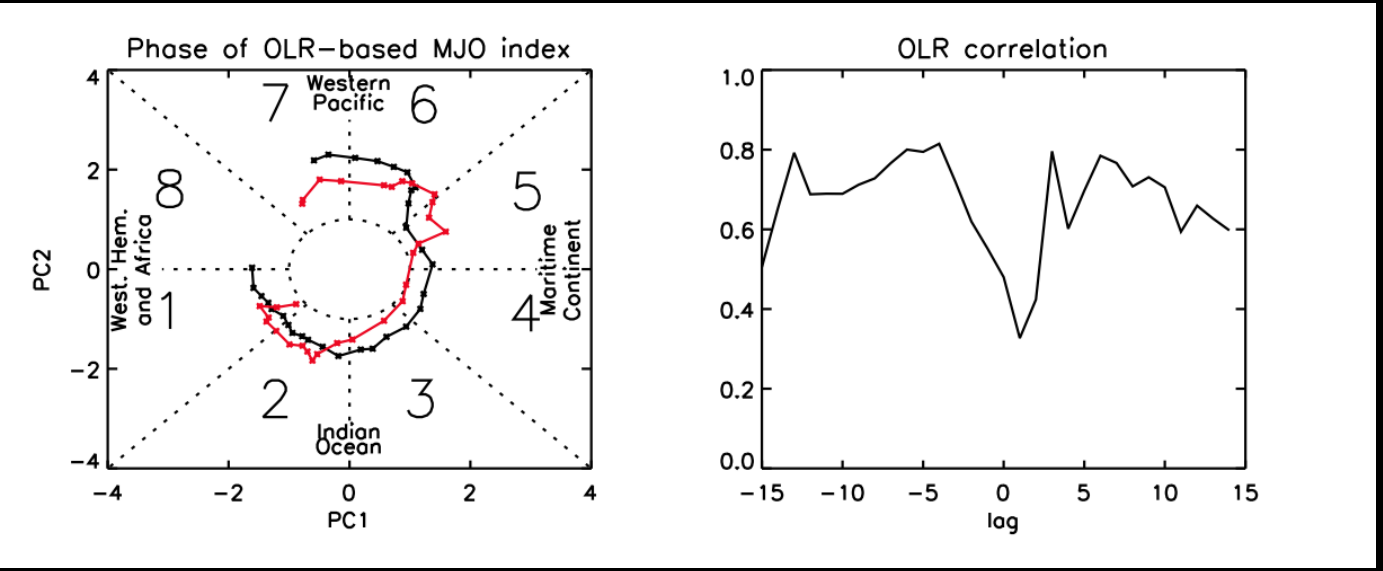

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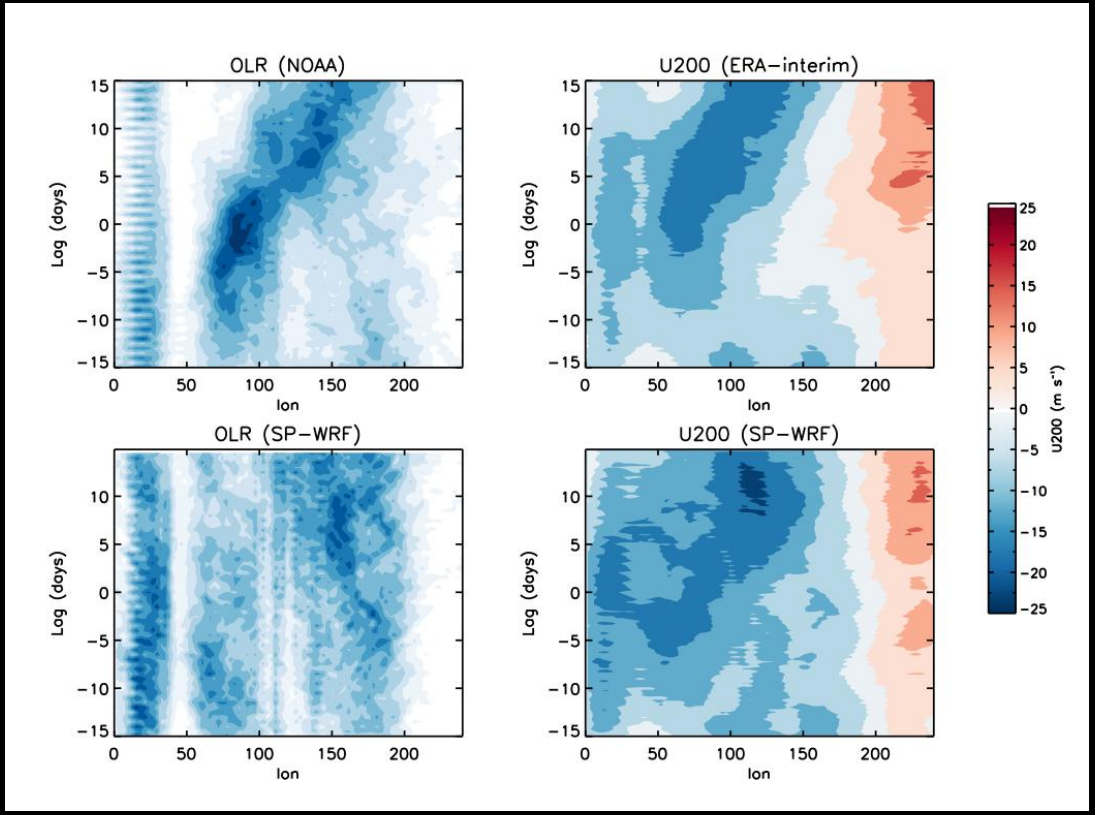
Conclusions

- Results demonstrate the utility of an ensemble-based event approach for MJO model development
- SP-WRF shows that increasing horizontal resolution can indeed improve model performance, given a sophisticated enough conv. parameterization
- Although not shown, we have also found that SP-WRF performance depends strongly on the bulk parameterization of surface fluxes

Impact of altering the treatment of surface fluxes due to gustiness



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